Geostatistical Modeling of Climate Variables at Regional Scales

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RESEARCH OBJECTIVES

The objective of this research is to develop, and illustrate the application of, a novel geostatistical framework for stochastic modeling of climate variables at regional scales. The developed approach allows for assessing explicitly the uncertainty in hydrological and environmental model predictions due to uncertain climate forcing, with wide applications to risk analysis in related impact assessment studies.

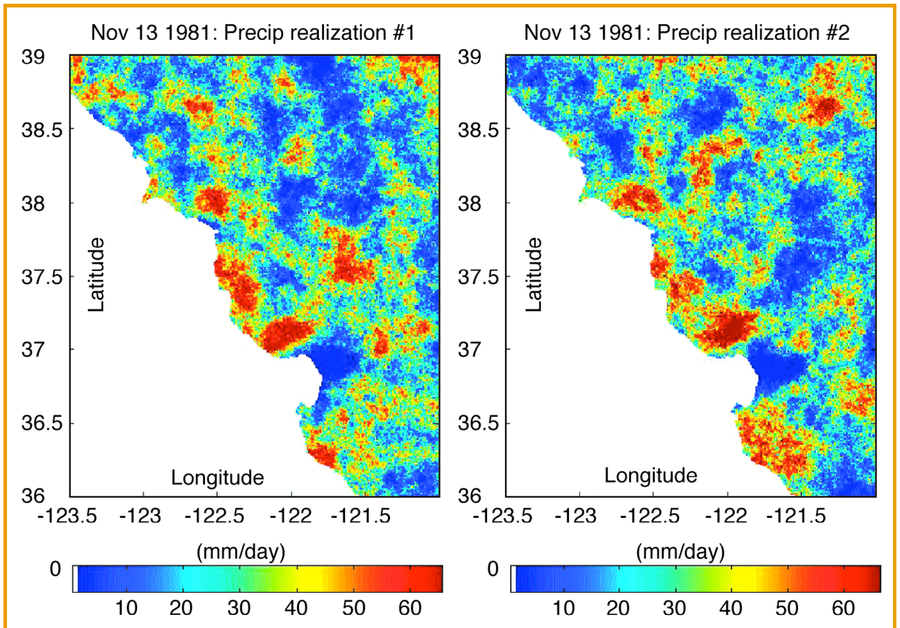

Figure 1. Two alternative simulated realizations of daily precipitation, at 1 km resolution, over the San Francisco Bay Area, for November 13, 1981

APPROACH

The developed geostatistical framework is based on stochastically assimilating (fusing) direct measurements of climate-related variables obtained at monitoring stations, and on ancillary (indirect) information provided by (1) terrain elevation and its derived products (e.g., slope, aspect) and (2) coarse-resolution predictions of climate variables obtained from dynamical downscaling, using a regional climate model. A novel adaptation of stochastic simulation in a space-time context enables the generation of realistic, fine-resolution, alternative synthetic realizations of climate variables at regional scales. These realizations are consistent with (i.e., reproduce exactly) the information available at coarser resolutions available in the form of dynamically downscaled predictions.

ACCOMPLISHMENTS

The development and application of the geostatistical framework for modeling daily precipitation over a region near the San Francisco Bay Area in a space-time context (Case 2 in the Approach section above) is showcased in Kyriakidis et al. (2003). Simulated precipitation realizations at a 1 km resolution were constrained by the available rain-gauge measurements and ancillary terrain-related information. They were shown to reproduce (a) the rain-gauge measurements and their histogram, and (b) a model of their spatiotemporal correlation. Two such simulated realizations are shown in Figure 1. The theoretical proof of mass preservation for the geostatistically derived fine-resolution predictions—that is, the exact reproduction of data available at a coarser resolution (Case 2 above)—is given in Kyriakidis (2003). Current work is focused on a case study illustrating how to apply stochastic simulation of fine-resolution daily precipitation subject to such coarser-resolution data constraints.

SIGNIFICANCE OF FINDINGS

The developed geostatistical framework constitutes a novel approach for the stochastic generation of realistic fine-resolution climate predictions, which can be used in a Monte Carlo setting for risk analysis in environmental and hydrological modeling. When coupled with regional climate model forecasts under future climate change scenarios, the geostatistical framework provides a novel approach to downscaling climate predictions at finer resolutions for more realistic impact assessment studies. The explicit account of the different data supports (i.e., the different volume informed by different types of measurements: rain gauge data versus regional climate model predictions) is a novel modeling characteristic not shared by any of the currently available statistical downscaling methods.

RELATED PUBLICATIONS

Kyriakidis, P.C., N.L. Miller, and J. Kim, A spatial time series framework for modeling daily precipitation at regional scales. Journal of Hydrology, 2003 (in press).

Kyriakidis, P.C., The geostatistical solution of the area-to-point spatial interpolation problem. Geographical Analysis, 2003 (in press).

ACKNOWLEDGMENTS

Support is provided by the NASA Office of Earth Science/Earth Science Applications Research Program (OES/ESARP) under Grant No. NS-2791.